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REPORT ON THE RESULTS OF THE PROBABILITY OF LIGHTNING CONDITION FORECASTING TEST CONDUCTED IN 2WW DURING MARCH, APRIL AND MAY 1977

BY

CAPT. R. G. BACHMAN

Published By
2ND WEATHER WING (MAC)
UNITED STATES AIR FORCE
31 JULY 1977

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Lightning strikes on in-flight aircraft constitute a significant and previously unforecast hazard to military aircrews in Europe. A logic-diagram technique was developed to forecast the probability of occurrence of all known weather conditions that relate to such strikes. The logic was developed by meteorological reasoning and modified on the basis of questionnaire feedback from aircrews routinely briefed. Though the results contained some pessimistic bias, indications from over 1000 responses were that (1) the

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service was desired by a significant number of crews, and (2) increasing probability values in the issued forecasts were associated with increasing likelihood of the crews encountering or seeing lightning events.

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REPORT ON THE RESULTS OF THE PROBABILITY OF LIGHTNING CONDITION FORECASTING TEST CONDUCTED IN 2WW DURING MARCH, APRIL AND MAY 1977

STATEMENT OF THE PROBLEM

I. Operational Considerations - Statistics compiled in several studies show that in Europe the frequency of lightning strikes to aircraft is over 3.5 times the worldwide average. The characteristics of the European weather environment combined with low level mission profiles are the primary causes. An USAFE RF-4 was lost in 1970 because of a lightning strike. Damage in 1976, though an exceptionally good weather year, was over $50,000. In previous years, damage costs have been considerably higher. Of primary concern is the potential loss of human life or another aircraft. Each year the number of aircraft incidents related to lightning and electrostatic discharge by far exceeds that of all other weather-related aircraft incidents. This problem affects all aircraft. It primarily concerns the F-4, F-111 and C-130, however, because they spend more time in low-level flight configurations. To our knowledge, no one in the past has attempted to provide forecast or advisory service of this phenomenon to inflight aircraft. It is well beyond the state of the art to forecast specific lightning strikes. However, it is well within our capability to identify areas where the threat of receiving a strike is relatively high or low. The problem then is how to do this effectively? During a visit, Col Guttuso, AWS/DN, suggested that we develop a system to issue these forecasts in probability terms and to verify them using customer feedback. Therefore, we developed this program to begin during the next lightning season, in 1977.

II. Meteorological Considerations - Statistical data on the weather conditions existing when strikes have occurred have been accumulated in several studies by both military and civilian agencies. The results are similar. First and most important is proximity to cumulonimbus clouds. Further, strikes normally occur between +10C, with the majority occurring on the cold side of the freezing level. The most likely reason for this is the existence of mixed-phase particles (ice and liquid) in this region. As would be expected then, most strikes occur below 15,000 ft. Also, most strikes have occurred while the aircraft was in precipitation, with a smaller number having occurred in clouds. The type of cloud

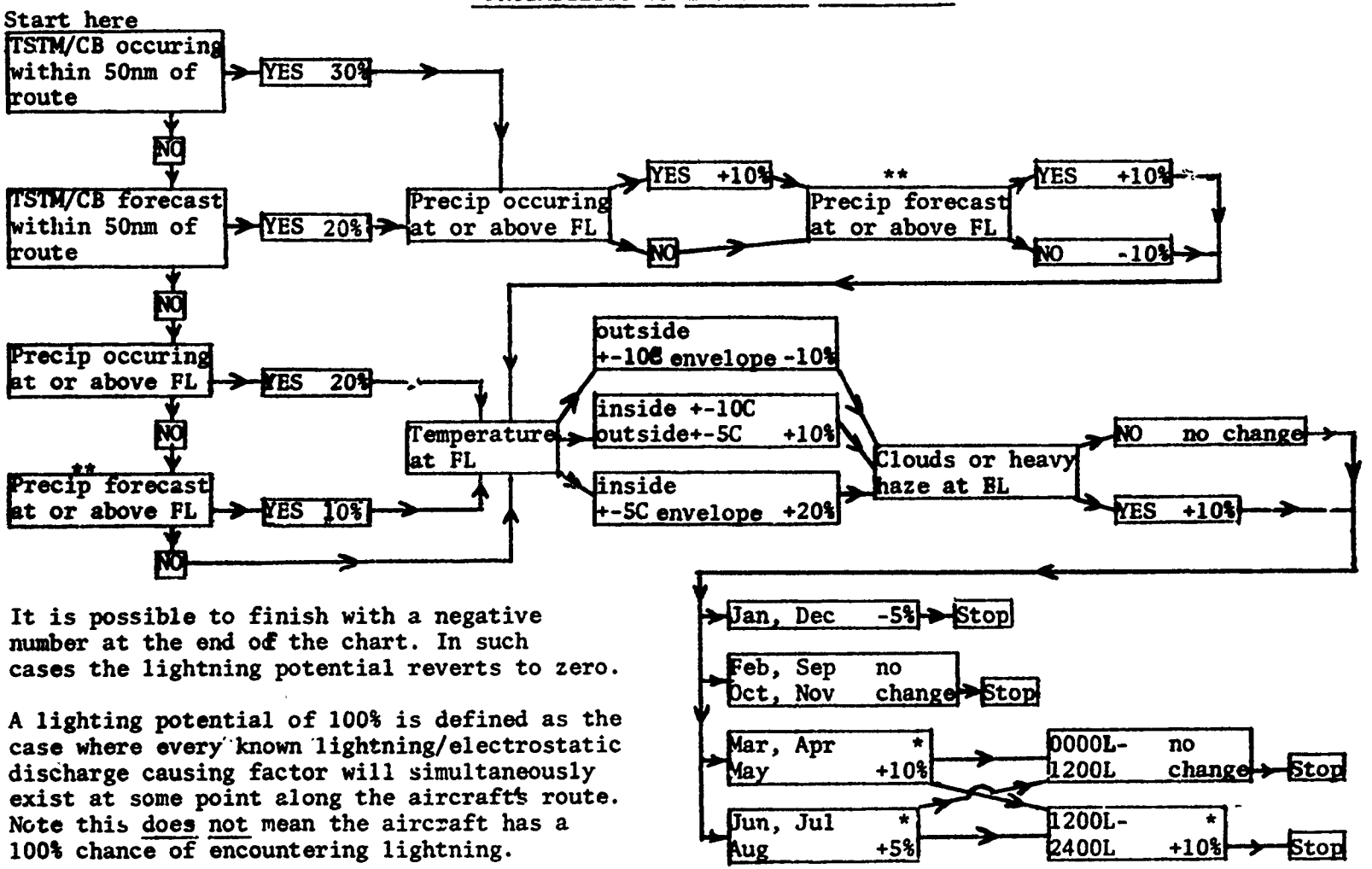
is important, but does not appear to be critical. This suggests that the electrostatic discharge mechanism is important. It is highly possible that aircraft penetrating nimbostratus clouds will inadvertantly penetrate imbedded CB clouds without the pilots knowledge. This may help to explain why many pilots report being struck with no thunderstorms (CB) present. We knew from a previous (1969) study conducted in 2Wx that the small thunderstorms and rain-showers (tops normally below 20,000 feet and often as low as 12,000 feet) common in Northern Europe are extremely potent, highly charged clouds. (These clouds are frequently referred to as cold CU.) These clouds are responsible for a large number of the strikes in Europe. More will be said about this type cloud, and the synoptic situation which causes them, later in the report. Additional data were available on frequency of strikes versus time of day and time of year.

PLAN

I. Title Selection - With the following information we proceeded to develop and test a technique to prepare forecasts of probability of lightning conditions (POLC). Some may wonder why we chose such a complex phrase for this program's title. Originally we considered lightning potential, but this was easily misunderstood. One could infer that with high probabilities we were forecasting specific strikes. This same argument applied to several other names which were offered. The semantics problem continues to plague us as a small percentage of the pilots are still unclear as to the intent of the forecast. This is despite an extensive effort at flying safety meetings, etc. to explain that the program tries to forecast only the conditions that cause lightning strikes. We know that actual strikes occur much less frequently.

II. Flow Chart - How to come up with an objective technique to make this forecast at first seemed a formidable task. The primary criterion, besides wanting something from which we could expect reasonable results, was that it must be simple and quick to use, since frequent reference would be made to it during the forecaster's busy work schedule. A flow chart or logic diagram (figure 1) seemed to be the best choice. The first iteration included all the atmospheric effects we were aware of and also the time-of-day and time-of-year factors. The initial assignment of probability values was done subjectively. The factors were listed in order of importance. Positive or negative probability values were assigned accordingly. The forecasters were required to use the flow chart in

PROBABILITY OF LIGHTNING POTENTIAL



It is possible to finish with a negative number at the end of the chart. In such cases the lightning potential reverts to zero.

A lighting potential of 100% is defined as the case where every known lightning/electrostatic discharge causing factor will simultaneously exist at some point along the aircraft's route. Note this does not mean the aircraft has a 100% chance of encountering lightning.

Among the factors not included in this chart are aircraft type, speed, whether it will be overflying ridges, church steeples etc. These factors must be considered subjectively.

* These additives apply only in TSTM/CB cases.

** Precip is forecast to continue until the aircraft passes through that given region.

FIGURE 1

preparing their forecast, but were encouraged to become familiar enough with the chart to arrive at the POLC almost automatically without continuous reference to it.

III. Questionnaire - To fullfill the requirement to evaluate the technique using customer feedback, a questionnaire was designed (figure 2). Each crew was provided a questionnaire during the flight weather briefings, with the request that it be completed when the flight was terminated and returned to the weather station. The form was also franked on the back so it could be mailed directly back to 2WW/DN. This questionnaire was to be provided in each F-4, F-111 and C-130 briefing given in USAFE base weather stations. Only long-haul flights given in regional briefing stations were exempted from the questionnaire requirements. However, forecasters were still required to brief the POLC. The probability entered on the questionnaire, when more than one applied, was always to be the highest POLC over the aircraft's entire route. The questionnaires were placed in the squadron briefing areas for telephone briefs or, at some units, were provided attached to the 175-1. A letter (figure 3) was approved and signed by the USAFE/DO, Major General Leavitt, to each of the AF Commanders in Europe to enlist flying organization support. This program was also publicized with a short article (figure 4) in the March Airscoop, USAFE's flying safety magazine. The questionnaire phase of this program was to run for five months from March through the end of July, but was cut back to three months to attempt to minimize the workload on both forecaster and aircrew members.

RESULTS

I. The flow Chart

a. The original flow chart (figure 1) had 16 steps. As stated earlier the probability values were assigned subjectively, with the more important factors receiving the highest absolute values. After the first month's data were analyzed, we found that our output probabilities were too high. Several adjustments were made in the flow chart to compensate for this. Blocks 11-16 were deleted entirely, and some of the percentages in the other blocks were reduced. Essentially the information in the deleted blocks 11-16 was accounted for automatically in the other sections. Our initial assumption that the flow chart was the major factor contributing to this pessimism was not entirely correct. As will be shown later, we apparently routinely overforecast the route weather conditions, especially thunderstorms, by a significant degree. In analyzing the flow chart, after we received this initial set of data, several errors in logic were noted. The temperature factors

LIGHTNING STRIKE QUESTIONAIRE

SECTION I. (Completed by the briefing forecaster)

Unit call sign_____ Date/time of T.O._____Type of aircraft_____
Route_____Destination_____

1. Indicate the probability of lightning condition briefed to the crew.

10-19% 20-39% 40-59% 60-79% 80-100%

2. Which blocks of the flow chart contributed (positively or negatively) to your resultant probability? 1___ 2___ 3___ 4___ 5___ 6___ 7___ 8___ 9___
10___ 11___ 12___ 13___ 14___ 15___ 16___

COMMENTS:_____

_____

SECTION II. (Completed by the aircrew member)

The forecast you have received for lightning potential was based on the factors listed below. These factors are known to be correlated with lightning strikes to aircraft in flight. Please indicate with a percentage of time, in the space provided, if any of these conditions effected your flight. Also indicate your flight level.

1. Thunderstorms/CB within 50nm of route? _____
2. Precipitation at flight level? _____
3. Clouds or heavy haze at flight level? _____
4. Flight level within plus or minus 10C of freezing level? _____
5. Flight level within plus or minus 5C of freezing level? _____

Please answer the following questions.

1. Did you see or encounter lightning during your flight? ___yes ___no
   If yes, indicate location_____
2. Did you observe a charge buildup on your aircraft or encounter St. Elmos fire, ball lightning, corona discharge, etc? ___yes ___no
   If yes, explain phenomena and location_____
3. Do you feel that the lightning potential which was briefed adequately covered the lightning/electrostatic discharge threat you experienced? ___yes ___no
4. Do you want a lightning potential briefed routinely? ___yes ___no

COMMENTS:_____

_____

This questionaire is part of a five month test to improve the AWS lightning potential forecasting quality. Your cooperation in completing this form and returning it to any USAFE base weather facility will assist us to serve you better in the future. If you can't make it to base weather, PLEASE RETURN THIS FORM TO Hq 2d Weather Wing/DN, APO 09012. Please note any route deviations in the comments portion of Section II.

FIGURE 2

DO&I

Lightning Strikes

3AF/CC 16AF/CV 17AF/CC

1. We are concerned about the lightning strike problem in USAFE. Insuring that every aircrew member has a thorough understanding of inflight avoidance measures will be a significant step forward. Your local weather unit can help. They are starting a program to improve their ability to support us in the lightning strike area. Your crews will be receiving probability forecast of lightning conditions at all future 175-1 weather briefings. For a limited period they will be asked to pick up a short questionnaire after each briefing, which should be completed at the termination of their flight and put in distribution. The purpose of the questionnaire is to evaluate the lightning potential forecasts which are provided, with the aim of improving them in the future.

2. We request your support and cooperation in this program. We need this kind of operationally oriented support from our weather units. Request you inform your flying organizations of this procedure.

LLOYD R. LEAVITT JR, Maj Gen USAF
DCS/Operations & Intelligence

1 Atch
Sample Questionnaire

FIGURE 3

AIRSCOOP ARTICLE (IN THE PATTERN) MARCH

FORECASTING THE VOLTS

Spring's the time of year for the grass to turn green, skies to show the sun for the first time since last fall, and white puffy clouds to occasionally get nasty and throw out electricity.

This last item is something to watch out for. European lightning likes USAFE iron birds on a three-to-one ratio as compared with the same aircraft flying in the states. Last year C-130s, F-111s and F-4s were struck in the command.

The weather forecasters at the 2nd Weather Wing are trying a new system so that they can better predict the conditions which cause electro-static discharge. They are asking our help in compiling background information so these conditions can be forecast.

They want you to fill out questionnaires at the termination of each mission. Basic information requested is call sign, route, type of aircraft, etc. Other specifics are thunderstorms noted within 50 nm of the route, precipitation at flight level, clouds or haze at flight level, and freezing level. If you have a telephone brief, the forms will be in the squadron. If you are briefed at ops, the weather officer will have the forms.

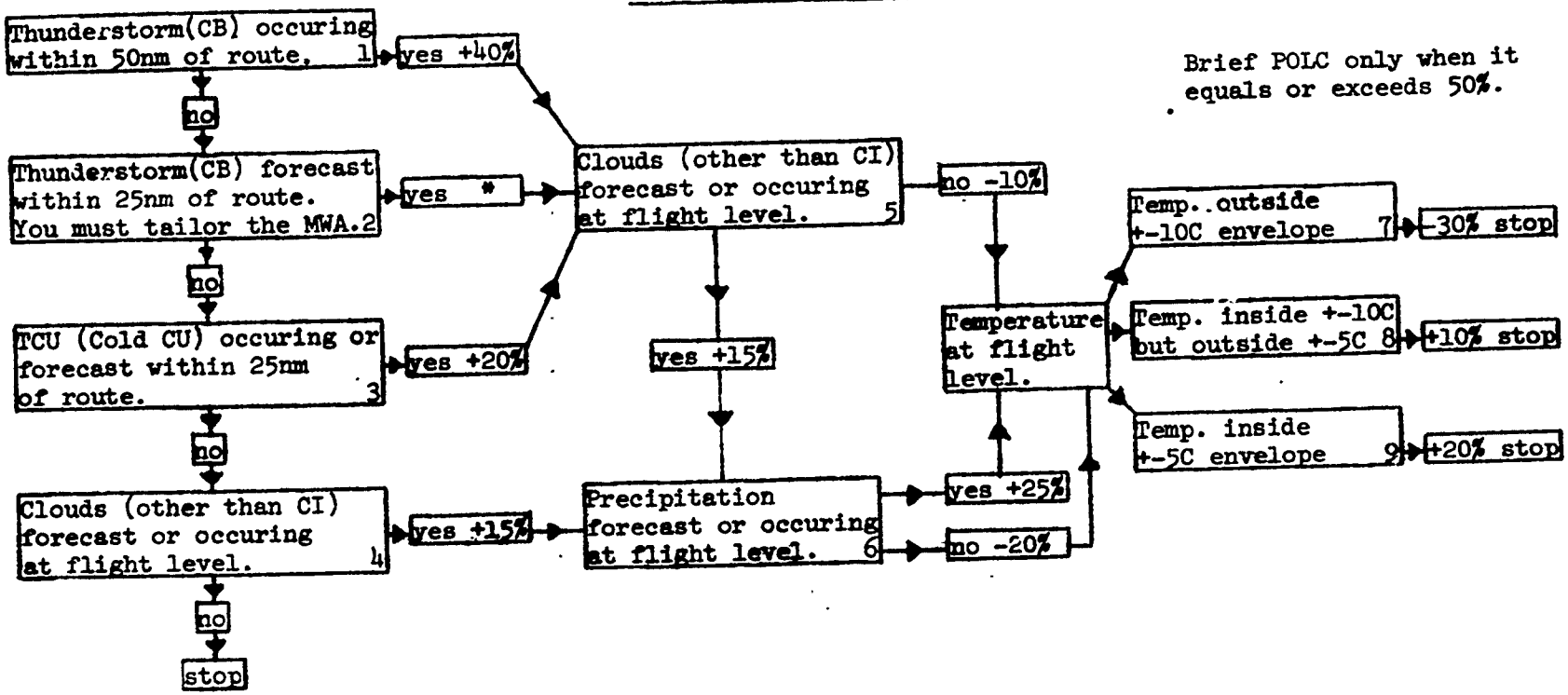
The whole program's designed to develop better forecasting methods -- to help us. The results will only be as good as the information we feed into the system.

FIGURE 4

are really significant only when the temperature range is encountered along with in-cloud or in-precipitation flight. By having the cloud block occur after the temperature blocks, the temperature factor contributed when it shouldn't have. Also, the cloud blocks were contributing points at the cirrus level when the flight level temperature was well outside the critical range. Several weeks of questionnaire data were received based on these changes; some improvement in the forecasts was noted. With analysis of all the data now completed, several more minor changes have been made. The final version of the flow chart with these alterations in shown in figure 6. It is somewhat shorter and easier to use than our original effort. The changes that have been incorporated were designed to make the technique discriminate between a significant lightning strike threat and one that is not significant. In addition, we have tried to take the pessimism and more of the uncertainty in our route forecasts into account.

b. Sample Forecast - Using a hypothetical situation, a demonstration of how to apply the flow chart to prepare a POLC route forecast may be useful. Assume a F-4 is taking off from airbase X, will do some high level work (FL 260), descent into a low level for a period, then climb back to 260 to return to home base. As in any good flight briefing the best way to approach this is to construct a "mental" time phase1 horizontal cross section of the aircraft's route in your mind. Proceeding through this flight chronologically: On takeoff the aircraft will penetrate a layer of AS clouds at 090-140 which are not precipitating and aren't expected to. The cloud layer falls within the ±5°C temperature range. Blocks 4, 6 and 9 of the flow chart apply as follows +15% - 20% + 20% = 15%. POLC here is less than 50%. At flight level 260 the aircraft is above all weather, so POLC will again be below 50%. On descending into the low level and during the entire period through climb out the aircraft is in an area of thunderstorms forecast with a Maximum Instantaneous Coverage (MIC) of 6% from the Military Weather Advisory (MWA). At present no thunderstorms are occurring and no other clouds are present, or are forecast to be. The forecaster's assessment of the MWA along with other factors (such as a stability analysis) gives a percentage from block 2 of 15%. The amount of expected coverage indicates the aircraft will have difficulty avoiding penetration of some of the buildups and the accompanying showers. Blocks 5 and 6 combined contribute 40%. The flight level temp in the low level will be +12C so block 7 applies. Summing up we have +15% + 40% - 30% = 25%. However, on entering and leaving the low level, the aircraft will go through the +5C temp envelope so the POLC sum is +25% + 40% + 20% = 85%. Returning to home base at FL260 once again the aircraft has a POLC well below 50%. By the time of letdown at home base, the AS layer has thickened

PROBABILITY OF LIGHTNING CONDITIONS



Brief POLC only when it equals or exceeds 50%.

A lightning condition of 100% is defined as the case where every known lightning/ electrostatic discharge causing atmospheric factor will simultaneously exist at some point along the aircraft's route. Note this does not mean the aircraft has a 100% chance of encountering lightning. Any aircrew briefed which is not familiar with this type of forecast must be briefed on its intent and purpose. The term "lightning potential" should not be used when providing this forecast as it is easily misinterpreted.

In order for the percentages to accumulate as you proceed through the flow chart the various factors must be collocated and be occuring simultaneously.

* Based on your forecast of thunderstorm potential assign a value here of 0-40% or use the values suggested below based on the MWA MIC values;

MIC 1-2% add 0-5%
MIC 3-5% add 5-10%
MIC 6-14% add 10-25%
MIC >15% add 25-40%

Prepared by JWW DNS July 77

and light rain is falling. Therefore, blocks 4, 6 and 9 will apply. Summing up +15% + 25% + 20% = 60%. The briefing given the crews is then as follows: "The POLC on descent and climbout to your low level will be 85% and on letdown here on your return will be 60%. During all other portions of your flight your POLC is less than 50%". In the case were POLC is less than 50% for the entire flight omit it completely from the briefing.

II. Questionnaire Response - Questionnaires were distributed from 1 Mar 77 until 31 May 77. In this period 1029 questionnaires were returned to 2WW/DN. It is not known exactly how many questionnaires were distributed. Seventeen weather units were involved in this distribution. Four of these had significantly reduced traffic levels for most of this period and at several other bases the program did not receive sufficient flying unit support. The participating units average about 20,000 175-1 briefings per quarter. From this we estimate the return of questionnaires represented approximately 5 - 10% of those issued. We had originally anticipated a 15 - 20% response. In the first month of the test the response was running at 20%, but interest wained in the latter period. In addition, 114 of those returned did not have Section II completed, so 915 questionnaires were usable. This small percentage of the potential response suggests some bias, especially when you consider that many of the forms were completed by the same person on subsequent flights through the period. Table 5 shows the number of responses by aircraft type. The F-4 response, while the largest in number, is probably the smallest in percentage since the vast majority of the sorties flown in USAFE are by F-4's. Despite the low response rate the number was sufficient to evaluate the procedure and make appropriate adjustments. In many respects this program amounted to operational verification (OPSVER) and points out the difficulties local units should expect if their OPSVER efforts depend on pilot feedback.

Table 5. Number of responses by aircraft type.

F-4	F-111	C-130	Other	Total
607	157	153	112	1029

III. Response Analysis - This section will review the responses to each of the blanks on the questionnaire.

a. Section I of the questionnaire was to be completed by the briefing forecaster, but since most briefings in USAFE are done by telephone the pilots had to complete this section most of the time. With the exception of the date and the route

information, the entries in this section were completed routinely. In item one 10-19% should have been 0-19%. All forecasters were aware of this. The entries in item two of this section proved valuable in trouble-shooting the flow chart and in after-the-fact analysis of the results. The average POLC briefed over the 3-month period was 39%. This figure is somewhat pessimistic. The implications of this will be discussed more later.

b. In Section II, completed by an aircrew member, the first five responses relating to thunderstorms/CB, precipitation, clouds and flight level temperature were used to evaluate the quality of the forecasts. As with most questionnaire surveys, the responses occasionally left something to be desired. The majority of the answers to the first three questions was yes or no rather than a percent of time as was requested. The questions on flight level temperature were frequently not answered, or a question mark was placed in these two blocks. Whether this meant the pilot didn't understand the question or didn't know his flight level temperature is not known. We must accept the blame for this, since a fighter's flight level is anything but constant. We could have done a better job of phrasing these two questions. What we really wanted to know was what the flight level temperature was when the items in questions 1-3 were encountered. Another troubling aspect of the entries in these blocks was an apparent tendency to put "no" in each block regardless of weather encountered. This was possibly brought on by the crew members impatience with the questionnaire (as expressed many times in the comments section). This bias can be noted in the results graphed in figures 7-11. Whether this is a bias on the pilot's part or simply pessimistic forecasts is impossible to tell. The method used to assign a probability based on responses to these five questions was as follows: A yes response counted 40% for question 1, 20% for question 2, 10% for question 3, 10% for question 4 if any or all of 1-3 were answered yes, and 20% for question 5 if any or all of 1-3 were answered yes. The data shows the forecasts were reasonable for the 0-19% group and the 80-100% group. In the middle ranges the median did shift to higher numbers with each successively higher forecast group, a fact which validates the technique; however, we were somewhat disappointed with these distributions. The strong zero and 10% bias, which has already been discussed, is one of the primary causes for the low median value. A normal distribution skewed to the median value was what we were looking for. In an effort to define the reason for the pessimistic forecasts, an analysis was done of the number of times thunderstorms

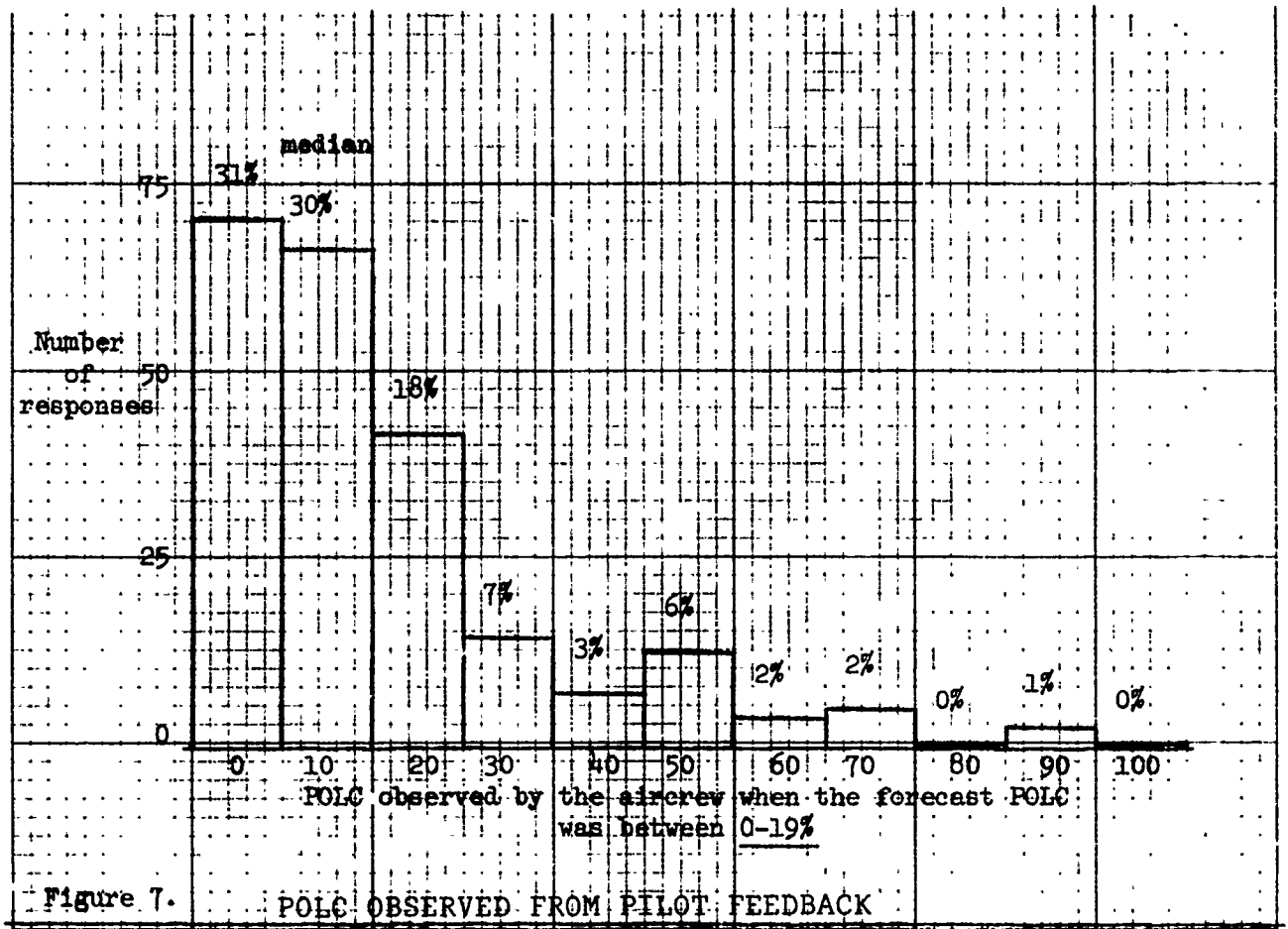


Figure 7. POLC OBSERVED FROM PILOT FEEDBACK

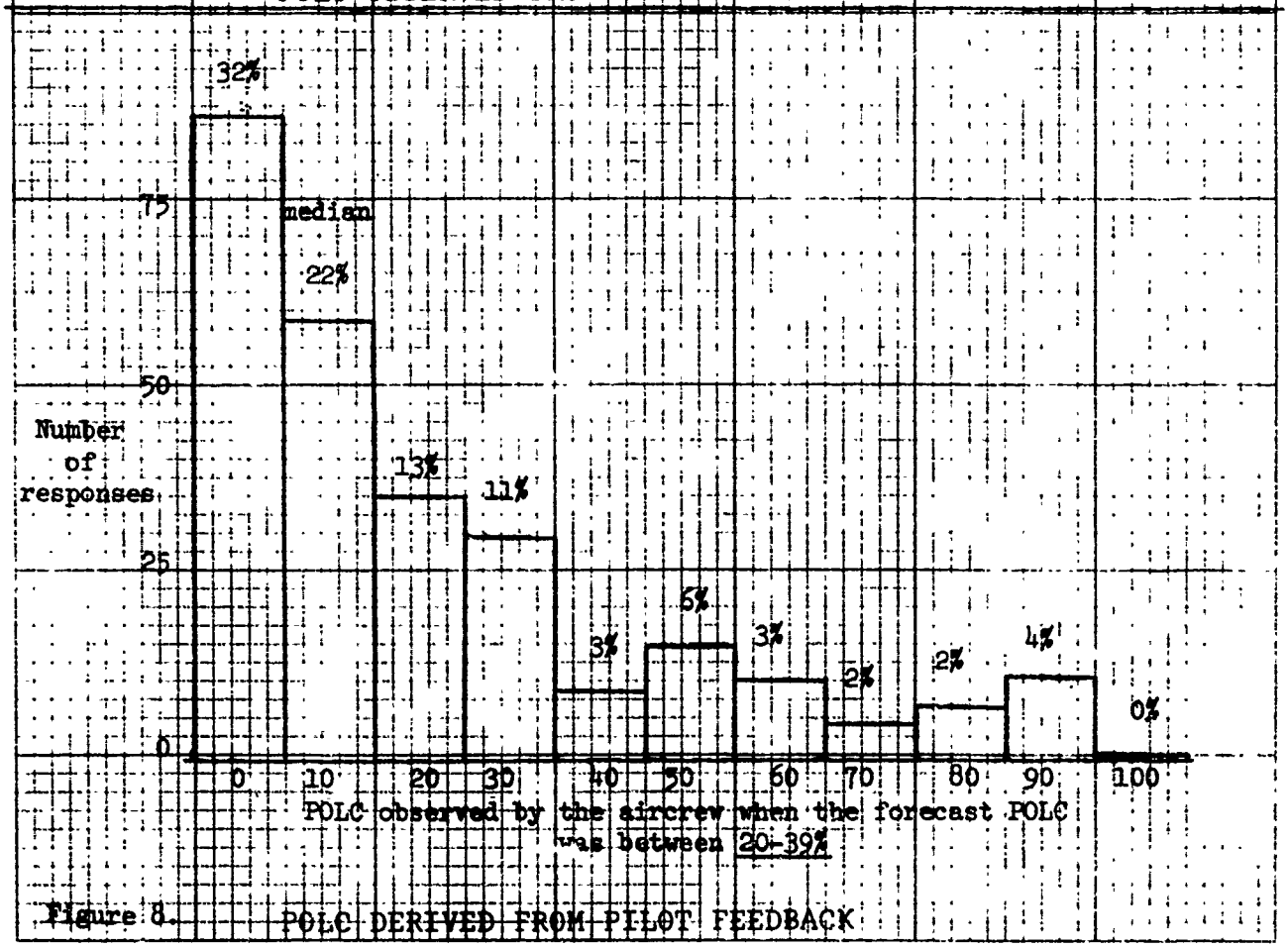


Figure 8. POLC DERIVED FROM PILOT FEEDBACK

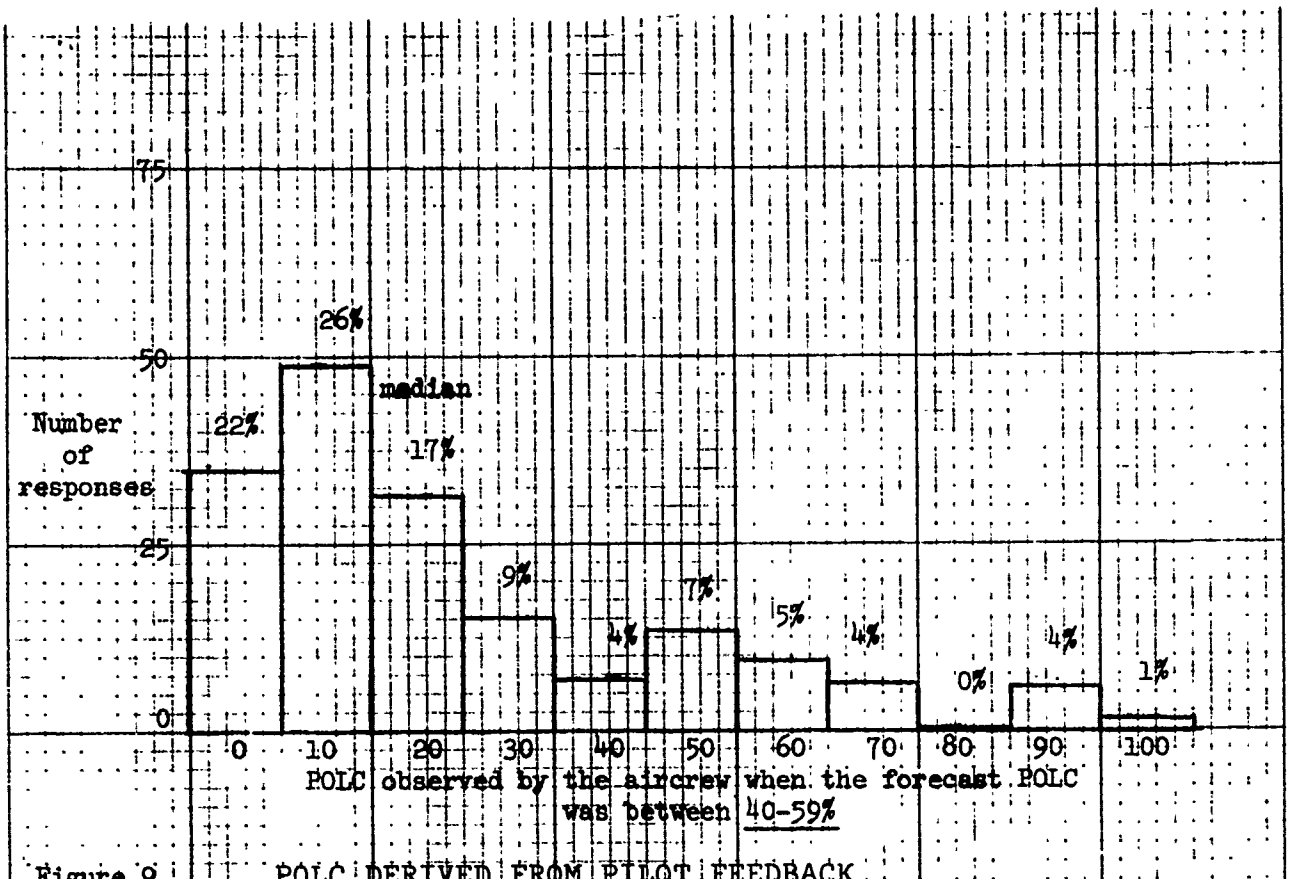


Figure 9. POLC DERIVED FROM PILOT FEEDBACK

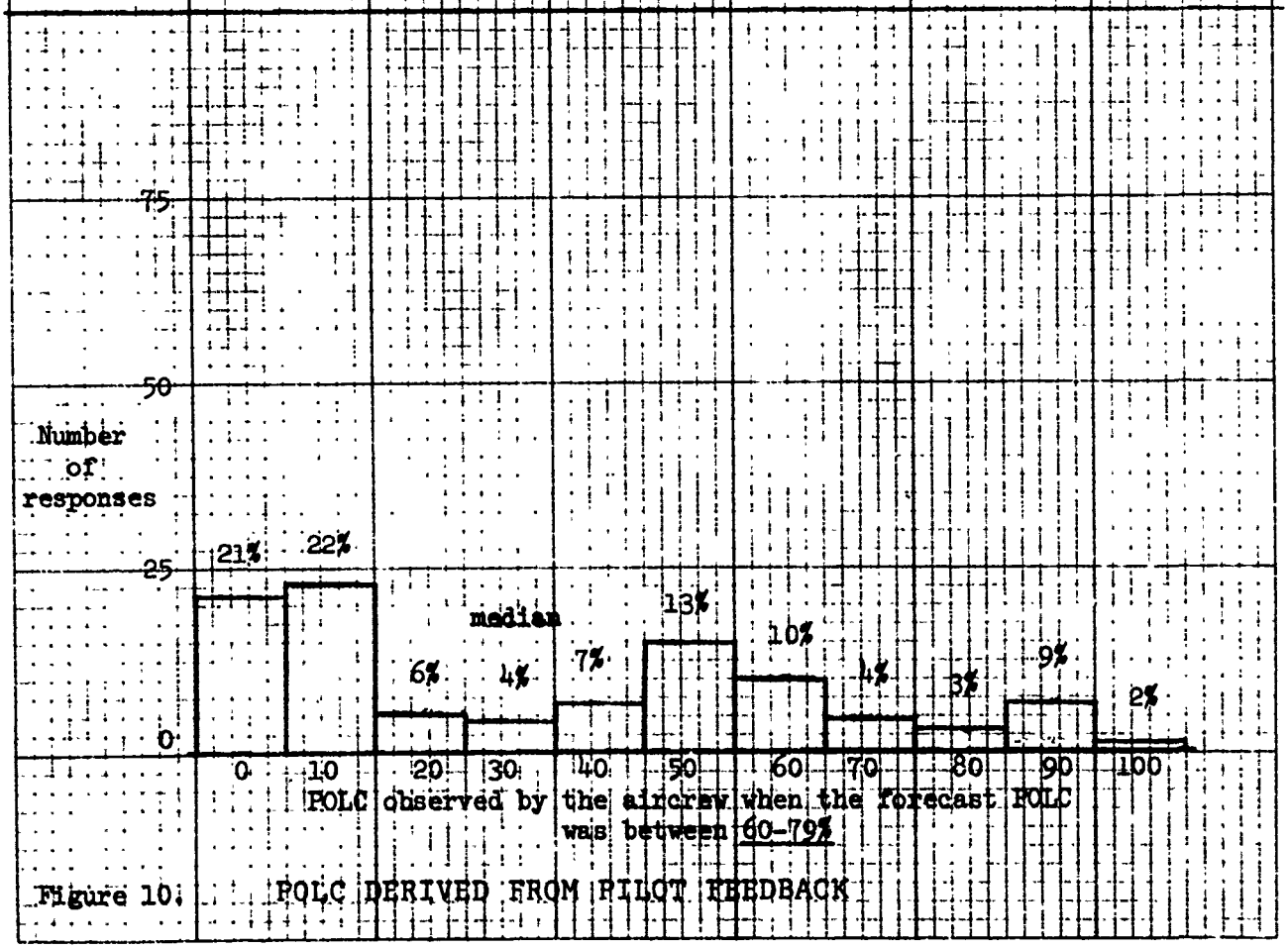


Figure 10. POLC DERIVED FROM PILOT FEEDBACK

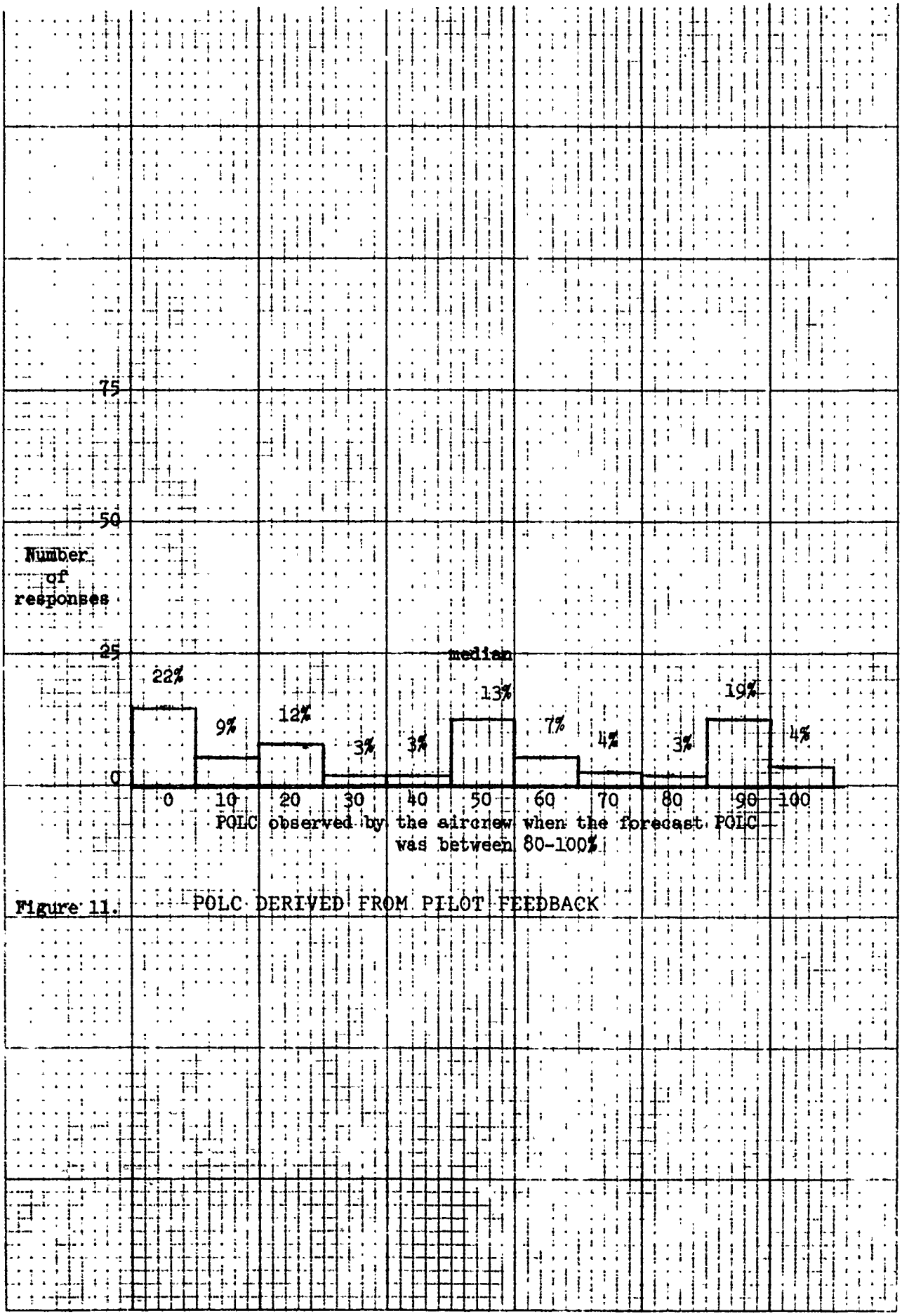


Figure 11. POLC DERIVED FROM PILOT FEEDBACK

contributed to the POLC versus the occurrence of thunderstorms reported by the pilots. The results are rather striking. We overforecast thunderstorms by a factor of 3.2 to 1. Thunderstorms were forecast 440 times, but occurred only 137 times. Also, thunderstorms occurred 25 times when they were not forecast. Most of these forecasts are based on the AFGWC Military Weather Advisory. Obviously the POLC technique will be only as good as the forecast which is used as its basis. More attention needs to be applied to the quality of our route forecasts especially when based on the Military Weather Advisory. The responses to the four questions on the bottom of the questionnaire were more reliable, primarily because they could be answered objectively with a yes or no. Our inexperience with questionnaires caused another minor problem. In the first question in this section we really asked two questions with the "see or encounter". Therefore, we were not 100% sure to which of these the answer pertained. Fortunately, in most cases the encounters were obvious from the way the other questions were answered.

1. Combining the results from questions 1 and 2, we found 12 encounters and 21 cases where lightning was observed. The average POLC briefed for the 12 strikes was 69%, with only one value being below 50%. Of the 21 nonstrike lightning occurrences, the average POLC was 41%. This is good evidence that the teqhnique does discriminate between high and low threat situations. Significantly, three of the twelve pilots who had encounters and nine of the twenty one who saw lightning reported that they did not see thunderstorms or CB along their route. One wonders if there is some pilot reluctance to admit getting close to a thunderstorm, since they will get a judgement call if they knowingly get close to a thunderstorm and experience damage. Once again, this suggests some bias in the results over which we had little or no control.

2. The response to question 3 showed that 86.5% of all the responses indicated the forecast which was provided adequately covered the lightning/electrostatic discharge threat that was experienced. This is further validation of the technique, although this figure is slightly higher than one would expect in view of the results displayed in figures 7-11.

3. The responses to question 4 shown in table 12, are broken dowr by aircraft type. The results indicate a sufficient pos itive result to continue providing this forecast service.

Table 12

F-4	F-111	All Others	Combined
28% Yes	29% Yes	56% Yes	40% Yes
170 Yes/437 No	45 Yes/157 No	149 Yes/265 No	364 Yes/915 No

Many of the "no" responses where a negative reaction to the questionnaire. The difference between the fighter and cargo aircraft are most likely a reflection of the different missions of these aircraft types and also the crews perceived vulnerability to adverse weather conditions.

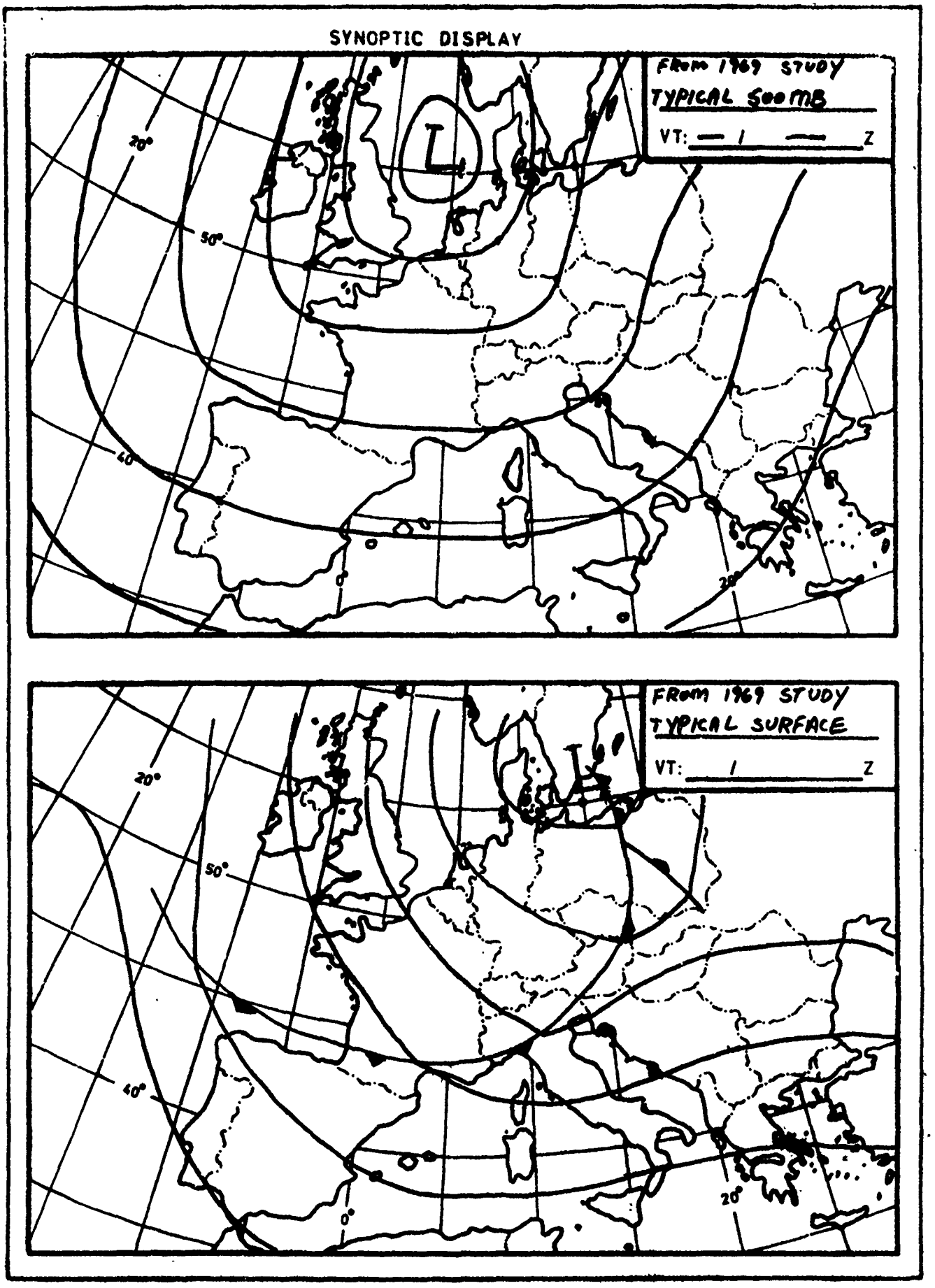
IV. Probability of Lightning Strikes (POLS) Estimate - The question of how to convert a POLC to an actual forecast of the probability of lightning strike (POLS) needs to be addressed. We do not have enough data to do this for all POLC values, but a reasonable estimate can be made for a POLC of 100%, from which a value can be inferred for lower POLC values. On the 14th and 15th of April a POLC of 100% existed over most of Europe. A case study of this situation is provided later. On these two days there were 13 lightning strikes. The average number of sorties for two days in USAFE is approximately 730. Dividing 730 into 13 results in a 1.8% actual probability of being struck. If we make the further assumption that the relationship between POLC and POLS is linear then a POLC of 50% represents a POLS of 0.9% and so on. The assumptions made here that all 730 sorties experienced a POLC of 100% can be challenged since the early morning sorties did not experience the level of cumulus activity that the afternoon flights did. However, a review of the synoptic reports indicates several stations carrying low cloud 3 (CB) at 09Z on the 14th. This assumption is therefore not as bad as it first appears. Of course this analysis does not consider the length of time that the aircraft remains in 100% conditions. Some allowance needs to be made for this factor, but it will vary with every flight.

V. Case Study - On the 14th and 15th of April there were 13 lightning strikes to aircraft flying in the European theater. Unfortunately, from these two days only 5 questionnaires indicating strikes were returned. The average POLC on those five questionnaires was 80%. Some of the entries on these questionnaire are incomplete, however, three of the reports appear to be electrostatic discharge and two are apparent lightning strikes. In each case that the data were reported the incidents occurred in low levels near the freezing level. With only two exceptions all the questions on conditions encountered were answered in the affirmative. One of the electrostatic discharge cases reported no thunderstorms and on one of the others the pilot indicated he was not within 5°C of the freezing level despite

a remark claiming his strike took place at -1°C, which is further evidence that the question was misunderstood. Of particular significance are the synoptic conditions, which existed on these two days, that could cause such an extraordinary number of strikes. Weather data were studied in detail for this period. The most important point found in this review was that the synoptic pattern was very similar to that identified in a study done by 2WW/DNS in 1969. An idealized surface and 500MB chart from the 1969 study is shown in figure 13, and maps of the surface and 500MB level from the 14th and 15th of April are shown in figures 14-15. These high probability situations develop when a moderate to strong surface front sweeps through the U.K. and over the continent. This frontal system will extend from a well defined closed low located over or near the Scandinavian peninsula. The surface system will be well supported by a deep and dynamic upper level long wave trough. The trough axis of the April system extended from the Western edge of the Scandinavian peninsula down through the Eastern Mediteranean into the mid-East. With this upper level flow a strong shot of very cold air aloft pushed down over most of Western Europe. Table 16 is a time phased analysis of the total totals stability index for Essen and Munich on the 14th and 15th. This data shows the peak instability period at Essen was during the 24 hour period from 14/12Z to 15/12Z; while at Essen it occurred from 15/00Z to 16/00Z. Significantly the geographic distribution of strikes fits this pattern. Notice also the very cool air at both 850 and 500 MB and its southward progression. This cold air moved over relatively warm ground, a fact that decreased the low level stability more than is reflected by the total totals index. Also this system was accompanied by fairly brisk low level winds which over the rough terrain of Western Europe provided an additional trigger mechanism for the many buildups which occurred. Radar data from Hahn, in West Central West Germany on the 14th reports CB tops averaging 120-130 with max tops 150, and on the 15th 150 with max tops of 220.

CONCLUSION

We have tackled a difficult problem and from a technical standpoint have had some success. Whether this new service will have significant operational impact is difficult to determine at this point. New ideas take some time to catch on. A sufficient number of our pilots want the service continued, so we can assume some degree of operational success. There are still questions to be answered from both a technical and operational standpoint. These will be addressed in the recommendations. At the present time the POLC forecasts are being issued, to all USAFE aircraft, when it equals or exceeds 50%.


SYNOPTIC DISPLAY
FROM 1969 STUDY
TYPICAL 500 MB
VT: — / — Z
L
20°
50°
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TYPICAL SURFACE
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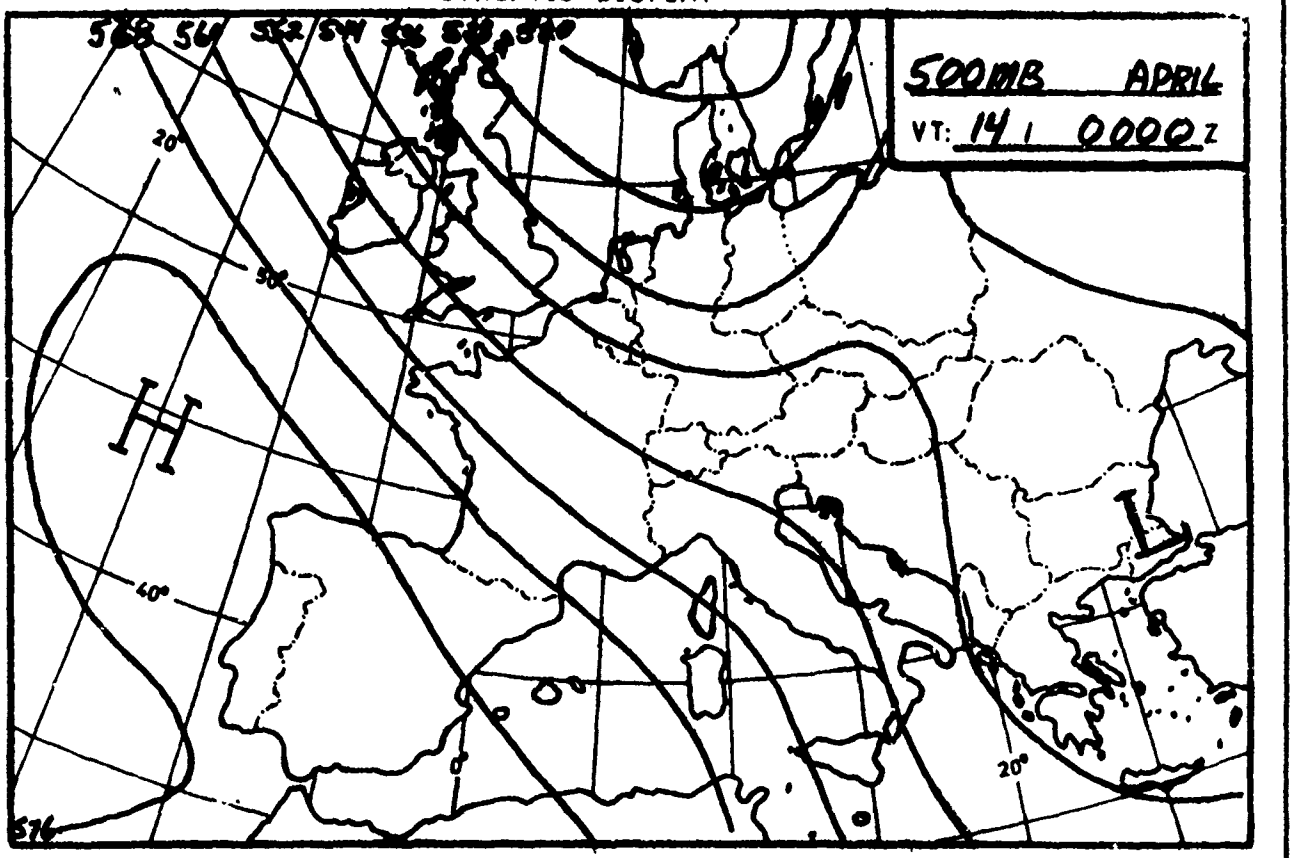
20°

FIGURE 13

SYNOPTIC DISPLAY



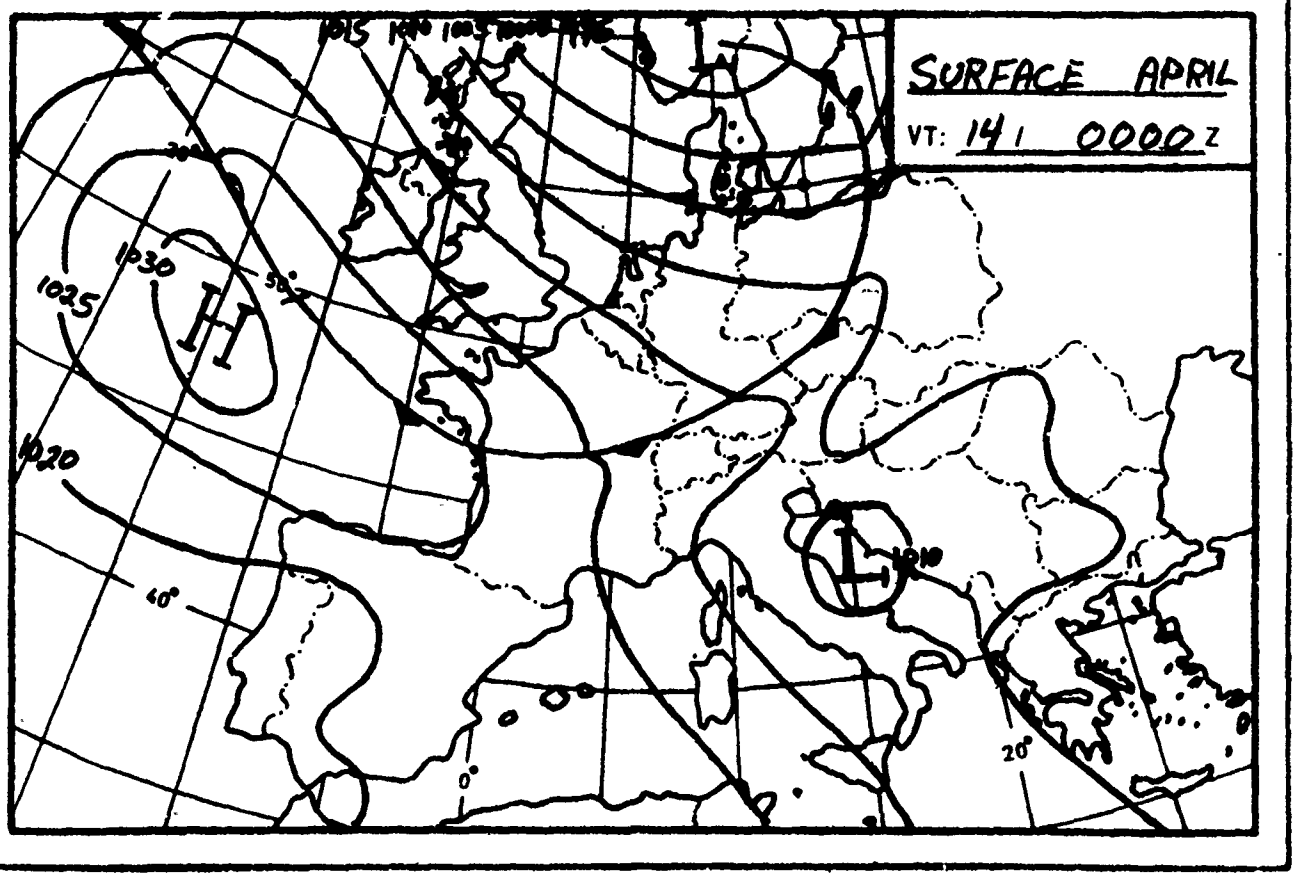
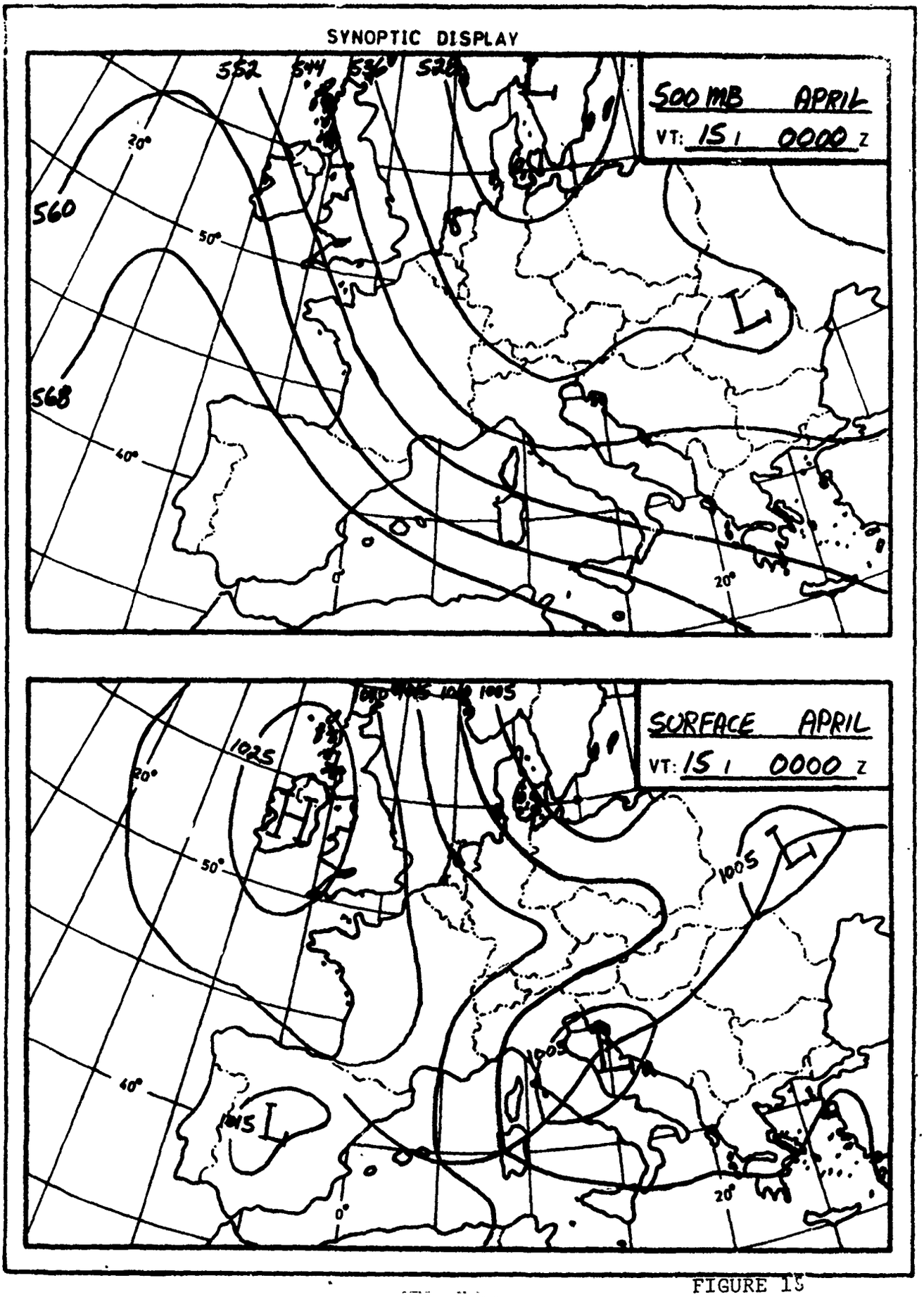


FIGURE 14


SYNOPTIC DISPLAY
552
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40°
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500 MB APRIL
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1005
1015
H
SURFACE APRIL
VT: 15 1 0000 Z

FIGURE 15

Table 16. Essen and Munich temperature, height and stability data (total totals index) from 13 - 16 April 1977.

ESSEN

Date/time	500mb hgt.	850 temp	850 dp	500 temp	TT index
13/00Z	557	1C	1C	-20C	42
13/12Z	549	1	1	-23	48
14/00Z	540	-3	-5	-30	52
14/12Z	534	-5	-8	-36	59
15/00Z	534	-6	-7	-35	57
15/12Z	539	-4	-5	-34	59
16/00Z	542	-8	-11	-29	39
16/12Z	551	-7	-8	-26	37

MUNICH

13/00Z	550	-4	-4	-25	42
13/12Z	555	2	2	-22	48
14/00Z	548	0	-2	-27	52
14/12Z	539	-3	-5	-31	54
15/00Z	533	-7	-8	-36	57
15/12Z	535	-6	-7	-37	61
16/00Z	537	-5	-6	-36	61
16/12Z	540	-7	-7	-31	48

RECOMMENDATIONS

I. Sufficient data has been gathered to validate the forecast technique and to show that we are close to a solution to this problem. However, the last revision of the flow chart needs to be evaluated to insure it is as bias-free as possible. We are rapidly nearing the end of this years lightning strike season, therefore, no further verification is suggested for this year.

Recommendation - Beginning on 1 April 1978 for a two month period questionnaires (revised, see pages 23 and 24) should be issued again. This data gathering should be done using one volunteer forecaster from each 31WS unit (or one appointed by the DETCO). This forecaster will request that each crew member he briefs complete a questionnaire. The question should be phrased such that this is an option, which the pilot can turn down without prejudice. The data collected will be only from willing and cooperative participants who understand what is wanted. OPR: 2WW/DNS.

II. Several aircraft which were struck by lightning in Europe this year had originated their flight and received their weather briefing in the CONUS or was briefed by a forecaster deployed from the CONUS with no knowledge of this program. Because of this a POLC forecast was not briefed.

Recommendation - All flights briefed in the CONUS should be briefed on a POLC (when it is equal to or greater than 50%) for their descent and landing at the European destination(s). This recommendation would involve both 7WW and 5WW units. 5WW units should also gear up to provide these forecasts when their support aircraft and forecasters are deployed to the European theater. OPR: 2WW/DNS.

III. In order to provide continuing quality control of our POLC forecasts and to continue to collect data in support of the AWS and AF wide effort to minimize this problem a continuing source of information in necessary.

Recommendation - Request that USAFE include in their lightning strike report, required from their flying units, a statement of the forecast and observed weather to include the POLC value for the area that the strike occurred. Also request the true airspeed of the aircraft at the time of the strike and that a copy of the message be info addressed to USAFE/WEN (Kapaun AB, GE).

SAMPLE QUESTIONNAIRE
(FOR 1978 POLC TEST)

SECTION I. (Completed by the briefing forecaster)

WX Station ID_____Date_____Type of Aircraft_____

Region of country flown_____

1. Highest POLC Briefed_____

2. Which blocks of the flow chart contributed (indicate a + or -) to the POLC briefed. 1___2___3___4___5___6___7___8___9___

SECTION II. (Completed by an aircrew member)

The forecast you have received of the probability of lightning conditions (POLC) was based on the factors listed below. These factors are known to be correlated with lightning strikes to aircraft in flight. Please answer each question as indicated.

*1. Thunderstorms along route _____Yes _____No

*2. Rainshowers (showery from buildups) along route ____Yes ____No

*3. Clouds (other than cirrus) at flight level _____Yes _____No

*4. Precipitation (steady non-convective) at flight level ___Yes___No

5. If and when you encountered phenomenia in 1 thru 4, what was your approximate flight level temperature? _____(or) What was your approximate flight level? _____

6. Circle the appropriate numbers, if applicable, if any or all of the factors, marked with an asterix, occurred simultaneously.

1 2 3 4

7. For the highest threat part of your flight, do you feel the POLC briefed to you adequately covered the lightning/electrostatic discharge threat you experienced? _____Yes _____No

8. Did your aircraft encounter any atmospheric electricl activity during your flight? _____Yes _____No Explain_____

If yes, what was your TAS?_____

9. Did you observe lightning along your route? _____Yes _____No

10. Do you want a POLC briefed routinely? _____Yes _____No

COMMENTS_____

_____

Thanks for your cooperation. Please return this form to any USAFE base weather facility or fold and put in distribution to HQ 2D Weather Wing/DN APO 09012.